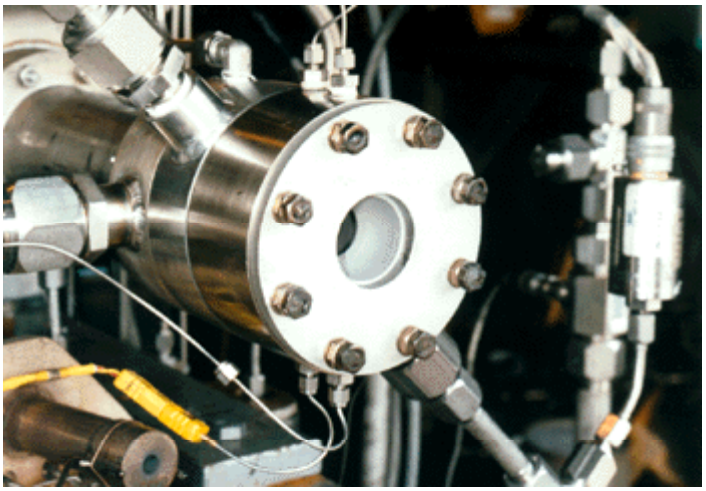
Ablative Material Testing at Lewis Rocket Lab

Ablative material sample prior to testing.

The increasing demand for a low-cost, reliable way to launch commercial payloads to low-Earth orbit has led to the need for inexpensive, expendable propulsion systems for new launch vehicles. This, in turn, has renewed interest in less complex, uncooled rocket engines that have combustion chambers and exhaust nozzles fabricated from ablative materials. A number of aerospace propulsion system manufacturers have utilized NASA Lewis Research Center's test facilities with a high degree of success to evaluate candidate materials for application to new propulsion devices.

Because of their knowledge of Lewis' extensive past experience in experimentally evaluating ablative materials (such as nozzle sections for rocket engines), TRW, Thiokol Corporation, and other companies submitted requests to evaluate new material compositions for Lewis. NASA Space Act Agreements were established to carry out these evaluations, utilizing samples supplied by the interested organizations, and the versatile rocket engine test facilities (Test Cell 22) at Lewis. A number of different composite materials were fabricated into nozzle inserts, with and without typical thrust chamber throats, and into as-throated disk samples. These samples were exposed to combustion gas temperatures of gaseous hydrogen and gaseous oxygen propellants from approximately 4400 °F to approximately 6000 °F at thrust chamber pressures from 500 to 900 psia.

Silica composite material samples provided by Thiokol were initially analyzed according to space shuttle experience, to predict the erosion of the nozzle liners to be tested. The primary goal was to minimize the ablative liner thickness and corresponding weight. The results of liner response from the rocket engine test stand show a wide range of erosion rates over test periods up to 341 sec, from negligible erosion for some ceramic composite materials to approximately 3.4×10^{-3} in./sec for some phenolic composites. These data provided key performance information for the application of low-cost, low-density materials. The test data from Cell 22 were also crucial to obtaining better "melt layer" models for silica composite materials.



Test cell 22 rocket engine with sample in place.

The samples provided by TRW and others included phenolic and ceramic matrix composites, some with protective throat coatings. As expected, the evaluation resulted in a wide range of durabilites for the composites under these severe operating conditions: the results verified some analytical predictions, and experimentally showed the limitations of other compositions.

These experimental evaluations were conducted in an expeditious and very productive manner, with excellent cooperation between personnel from NASA Lewis and the other companies involved. Thiokol Corporation is currently under contract to the Rocketdyne Division of Rockwell, which is the rocket engine contractor to McDonnell Douglas. The rocket engine test stand, Cell 22, will provide continuing investigation of test coupons, liners, and nozzles with a very cost effective, fast-paced schedule. The other companies involved have expressed interest in providing additional samples for evaluation in the near future.